NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

December 2, 2013

MATERIALS LABORATORY FACTUAL REPORT Report No. 13-083

A. ACCIDENT INFORMATION

Place	:	Paulsboro, New Jersey
Date	:	November 30, 2012
Vehicle	:	Conrail Freight Train FC4230
Operator	:	Consolidated Rail Corp. (Conrail)
NTSB No.	:	DCA13MR002
Investigator	:	Paul Stancil, RPH-20

B. COMPONENTS EXAMINED

1) Two sections of Trinity Industries DOT 105A300W Vinyl Chloride Tank Car, Reporting Mark: OCPX 80234;
    a. Section containing breach through tank car shell;
    b. Section of undamaged tank car material;
2) Columbus Casting tank car coupler with fractured lower shelf, A.A.R. Catalog No.: SE 60 EE.

C. DETAILS OF THE EXAMINATION

On Friday, November 30, 2012, at 6:59 a.m. EST, southbound Consolidated Rail Corporation (Conrail) freight train FC4230 consisting of two locomotives and 82 cars derailed seven cars, the 6th through the 12th, near milepost 13.7 on the Conrail Penns Grove Secondary track in Paulsboro, New Jersey. The derailment occurred as the train traveled over the Paulsboro moveable bridge.

Four tank cars that derailed on the bridge came to rest with portions of the cars in Mantua Creek. Three of the derailed tank cars that entered the creek contained vinyl chloride, and one contained ethanol. One of the tank cars was breached during the derailment and released approximately 20,000 gallons of vinyl chloride into the environment (see figure 1).

The breached tank was manufactured by Trinity Industries, Inc. in 1990 to the DOT105A300W specification for pressurized tank cars. DOT105A300W tanks are insulated, are pressure tested to 300 psi, and have a rated burst pressure of 750 psi. The tank was manufactured from TC128 grade B steel plate. The cylindrical shell portion of the tank was made from four steel plates with a minimum wall thickness requirement of 0.5625 inch by forming each plate into a ring, welding the longitudinal seam of each ring, and then joining the rings with circumferential double submerged-arc welds (DSAW). The heads at each end of the tank were made from steel plate formed into a semi-elliptical shape and welded to each end of the shell. The heads also had a minimum thickness requirement of 0.5625 inch. The ends of the tank car were labeled “A-end” and “B-end”. The breached tank car was travelling with the B-end in the lead and the A-end following.

A visual examination indicated that a tank car coupler had breached the tank and that the breach initiated at or near a circumferential weld located midway along the length of the shell on the left side of the tank (when viewed facing the direction of travel). Two sections of material were cut from the breached tank and sent to the NTSB Materials Laboratory for examination and testing. The first section contained the breach and measured 8 ft by 4 ft (figure 2a). The second section was cut from the opposite side of the tank car and was centered about the same circumferential weld where the breach had occurred (figure 2b). The section contained undamaged weld and shell material on the A-end and B-end sides of the weld and measured 4 ft by 3 ft. The tank car coupler from the leading car, found inside the breached tank, was sent to the laboratory as well (figure 3).

A group exam of the above-mentioned items was held in Ashburn, VA and Washington, DC from September 25, 2013 through September 27, 2013. The members of the group included:

1) Donald Kramer, Ph.D., Sr. Materials Engineer, NTSB
2) Eric Levin, Consolidated Rail Corp.
3) A.D. McKisic, Trinity Industries, Inc.
4) Allen Richter, Consolidated Rail Corp.

Additional external laboratory testing was conducted after the conclusion of the group exam. The findings of the group exam and the external laboratory testing are reported in the sections that follow.

1. Breached tank section and tank car coupler: Visual and non-destructive evaluation

The breached section of the tank was examined visually and the dimensions of several features were measured using a steel ruler and measuring tape. There was a scratch track on the outside of the tank that started approximately 13 inch from the weld on the B-end side, as shown in figure 4, and increased in width and depth until it intersected the weld. Near the toe of the weld, the scratch was approximately 2.0 inch wide and 0.7 inch deep (figure 5). There was a tear along the lower edge of the scratch track that started at the toe of the weld and extended 2.8 inch back toward the B-end (figure 5).

The shell wall was fractured in the circumferential direction at/near the toe of the weld on the B-end side along a length of approximately 2.5 inch (see the laboratory examination section below for a metallographic cross section through the weld). At each end of the circumferential fracture, the fracture path turned and continued along the longitudinal direction of the tank fracturing the weld and producing two approximately 17-inch long tears on the A-end side of the weld. The distance between the tears started at 2.5 inch near the weld and it increased to approximately 5.7 inch near the end. The material between the tears had curled inward as shown in figures 6 and 7. The tears then opened into an irregularly-shaped hole with additional curling and inward deformation that folded sections of the wall inside the shell as shown in figure 6. The hole measured 37 inch at its widest. On the A-end side of the weld, a second scratch track appeared below the lower tear and the combined width of the tears and the second scratch track was approximately 11 inch. Just before the tears opened into the hole, a third scratch track appeared below the second scratch track (figure 4).

The wall thickness of the tank section was measured on the B-end side of the weld using an ultrasonic thickness gage in an undeformed area. The tank wall thickness measured 0.605 inch and exceeded the minimum wall thickness requirement of 0.5625 inch.

The welds on the two tank car pieces, including the 2.5 inch length of fractured weld that was attached to the curled material (adjacent to the breach initiation site), were examined by radiographic inspection and the radiographs were compared to the acceptance criteria in the AAR Manual of Standards and Recommended Practices Section C-III: Specifications for Tank Cars (AAR, 2007). The weld sections met the acceptance criteria with the exception of a discontinuity adjacent to the failure initiation site that was identified as a crack on the weld inspection report (see section C.2 and figure 11a below). See Appendix A for the radiographic inspection report.

The fractured tank car coupler was visually examined. Photographs of the coupler are shown in figures 3, 8, and 9. The aft end of the coupler consists of a knuckle which couples the leading and trailing car, an upper shelf, and a lower shelf. The lower shelf is of a similar size and shape as the upper shelf but is offset laterally. The shelves limit relative vertical displacements of the knuckles that might otherwise lead to decoupling of the cars. The bottom shelf on the coupler was fractured as indicated in figures 8 and 9. Near the aft portion of the shelf, the fracture surface was rough and had an appearance consistent with a cast microstructure. As the fracture proceeded toward the forward portion of the shelf, the fracture surface developed a shear lip. The fracture features were consistent with an overstress fracture in forward bending.

The fracture at the weld and the surrounding material was cut from the tank car for laboratory examination using a plasma cutter (figure 10). Additional specimens were cut from the tank sections for testing and examination as follows:

- Tensile testing of A-end side and B-end side material from the undamaged section;
- Chemical analysis of A-end side and B-end side tank car material from the undamaged section;
- Hardness testing of weld material from the breached section;
- Metallurgical cross section through the circumferential weld from the undamaged section;

- Tensile testing of weld material from the breached section;

2. Laboratory examination

The fracture at the weld was cleaned first by using an alkaline detergent and a nylon bristle brush, second by sonication in acetone, and finally by acetate replicating tape softened with acetone. The fracture surfaces were then examined using a stereomicroscope and photographed as shown in figures 11a and b. The fracture surfaces had a rough and smeared appearance. A lip of material was observed on the B-end side along the inside of the shell wall and a corresponding lip of material was observed along the edge of the weld bead on the outside of the shell wall (not shown). The features were consistent with a ductile shear overstress fracture.

The feature identified as a crack on the radiographic inspection report was visible on the fracture surface adjacent to the weld bead as indicated in figure 11a. The feature was a tear that started along the inside of the shell wall and progressed radially outward before turning and following a circumferential path. There was no analogous feature on the mating fracture face (figure 11b). Similarly, there was no analogous feature to the tear on the B-end side of the weld, previously described, on its mating fracture face. As shown in figure 11a, the weld and material on the A-end side of the weld were curved radially inward due to bending deformation about the longitudinal direction of the shell. The same degree of bending deformation was not observed in the shell wall on the B-end side.

Metallurgical cross sections through an intact section of the weld and through the fracture near the weld were prepared using standard metallographic procedures in accordance with ASTM E3 – 01. The polished cross sections were etched with a mixture of 98% methanol and 2% nitric acid (Nital etch). An image of the intact weld cross section is shown in figure 12 and an image of the fracture near the weld is shown in figure 13. The appearance of the weld was consistent with the DSAW process with the first welding pass along the inside of the shell and the second welding pass along the outside of the shell. The microstructure of the steel on both sides of the weld had a fine-grained appearance, as shown in figure 14, consistent with the microstructure requirements for TC128 grade B steel (AAR, 2007).

The cross section through the fractured weld indicated that the fracture started at the toe of the weld on the inside of the shell and progressed away from the weld, through the heat-affected zone, and into the base metal where it remained through the rest of the wall section. The microstructure of the heat-affected zone was examined at higher magnification. Next to the fusion zone, the heat affected zone had a coarse grain appearance, with occasional proeutecoid ferrite located along prior austenite grain boundaries and needle-shaped (Widmanstätten) ferrite with secondary phases inside the prior austenite grains (figure 15a). With increasing distance from the fusion zone, the microstructure became increasingly refined with an appearance similar to the parent metal microstructure but with a finer grain size (figure 15b).

Also visible on the cross section was the reduction in thickness to the shell wall on the B-end side of the weld (see figure 13). The wall thickness, as measured by a micrometer at one location close to the fracture, was reduced to 0.4214 inch.

The hardness of the inside and outside weld passes was measured three times on sections of the weld that were ground flat on their respective faces (also leveled on the backside). The hardness measurement procedure was carried out in accordance with ASTM E18 – 03e1. The hardness values on the outside weld were 12.2 HRC, 14.8 HRC, and 14.7 HRC. The hardness values on the inside weld were 9.3 HRC, 10.1 HRC, and 8.7 HRC. All hardness values were below 20 HRC, in accordance with the AAR specification (AAR, 2007).

3. External laboratory testing

Samples for tensile testing of the tank material on the A- and B-end sides of the weld and of the weld were sent to a commercial laboratory. The samples were prepared and tested in accordance with ASTM A370-12a and the AAR tank car specification. All base metal and weld metal specimens met their respective mechanical property requirements. See tables 1 and 2 for a summary of the mechanical property data, Appendix B for the laboratory test report, and Appendix C for the original steel mill test reports that contain the original mechanical test data for the plates that were used in the construction of the shell.

Samples of the tank material were sent to a commercial laboratory for chemical analysis. The chemical composition of the material on the A- and B-end sides of the weld met the requirements of the material specification for TC128 grade B that were in effect at the time the tank was fabricated. See Appendix D for the laboratory test report, Appendix E for the relevant TC 128 grade B chemical composition requirements, and Appendix C for the mill test reports that contain the original heat analysis.

D. REFERENCES

AAR. (2007). *Manual of Standards and Recommended Practices Section C-III – Specifications for Tank Cars*. Washington, DC: American Association of Railroads.

Donald Kramer, Ph.D.
Sr. Materials Engineer

Table 1: Mechanical test data for the tank car material on the A-end and B-end sides of the weld. The values are the average of three test specimens. Standard deviations are given as are the requirements for TC128 grade B material.

Source	Yield Strength, 0.5% extension under load, ksi	Yield Strength, 0.2% offset, ksi	Tensile Strength, ksi	Elongation in 2 inch
A-end	67 ± 2	68 ± 2	89 ± 2	35% ± 1%
B-end	65 ± 0	66 ± 1	87 ± 0	36% ± 2%
AAR TC128 grade B Requirement	50[1] (min)	50[1] (min)	81 to 101	22% (min)

Table 2: Mechanical test data for the circumferential weld. The values are the average of three test specimens. For comparison, the requirements from the specification are also given (AAR, 2007).

Source	Tensile Strength, ksi	Elongation[2]	Location and Character of Failure[3]
Weld tension specimens from breached section	92 ± 1	31 ± 2	Base metal/ductile
AAR Joint-Tension Test Requirement	81 - min	—	—

[1] The material specification for TC128 grade B allows either the 0.5% extension under load or 0.2% strain offset method to be used for determination of yield strength.
[2] This measurement is provided for information purposes only. There is no elongation requirement per the specification.
[3] This observation is provided for information purposes only. An observation of the location of failure is only required per the specification if the tensile strength of the weld test specimen is between 95% and 100% of the tensile strength requirement for the base metal.

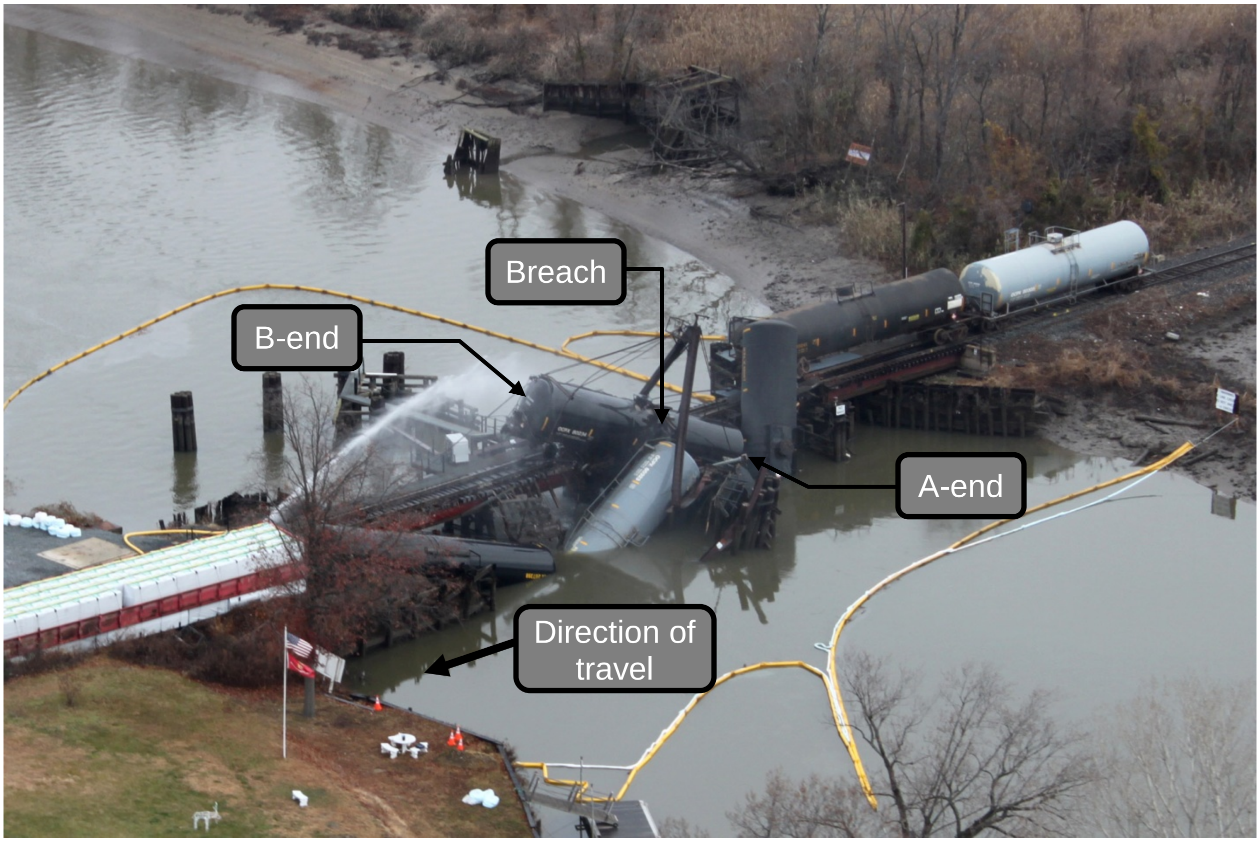


Figure 1: Aerial photo with the A-end, B-end, and approximate location of the breach in the tank car identified.

Figure 2: a) 4 ft by 8 ft section of vinyl chloride tank car OCPX 80234 containing the breach and b) 4 ft by 3 ft section from the opposite side of the tank car containing the same circumferential weld and ring material on either side. The location of the weld on each section is indicated by a series of yellow arrows.

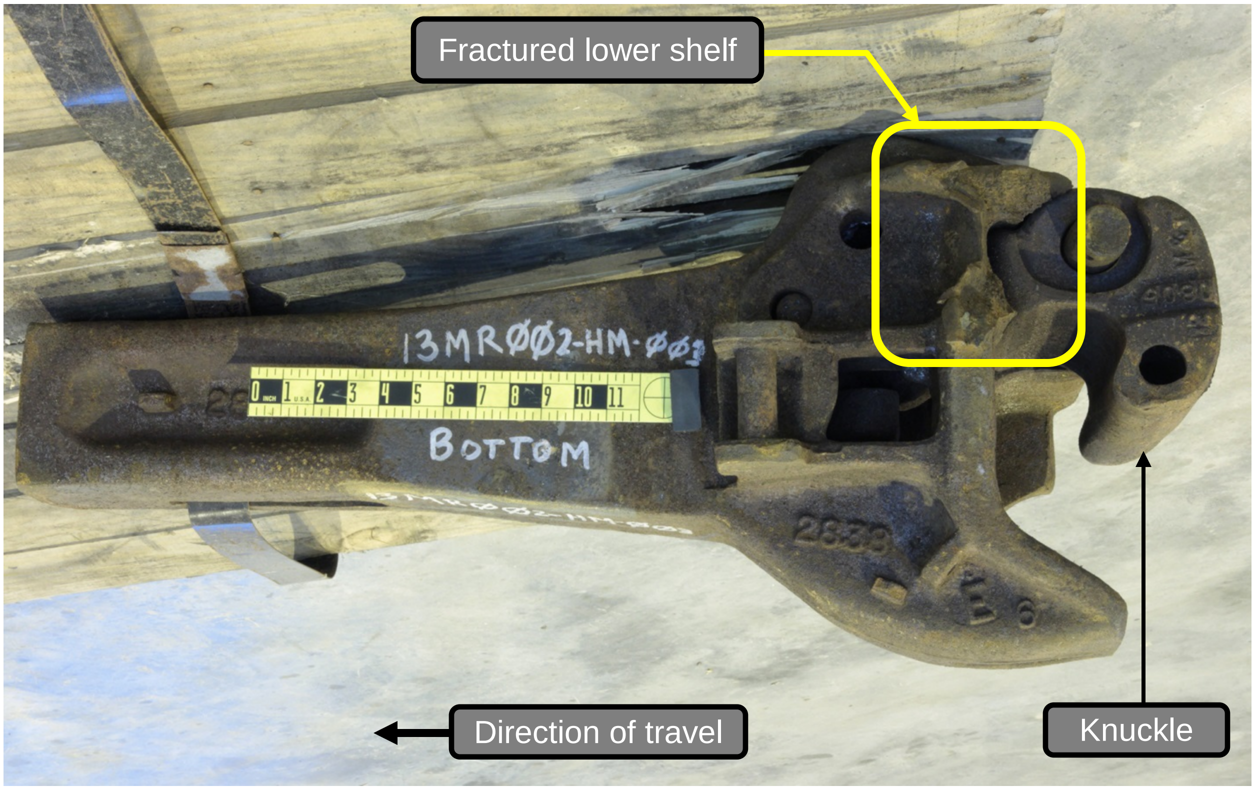


Figure 3: Underside view of the tank car coupler from the leading car that was found inside the breached tank. The location of the fractured lower shelf is indicated in the figure.

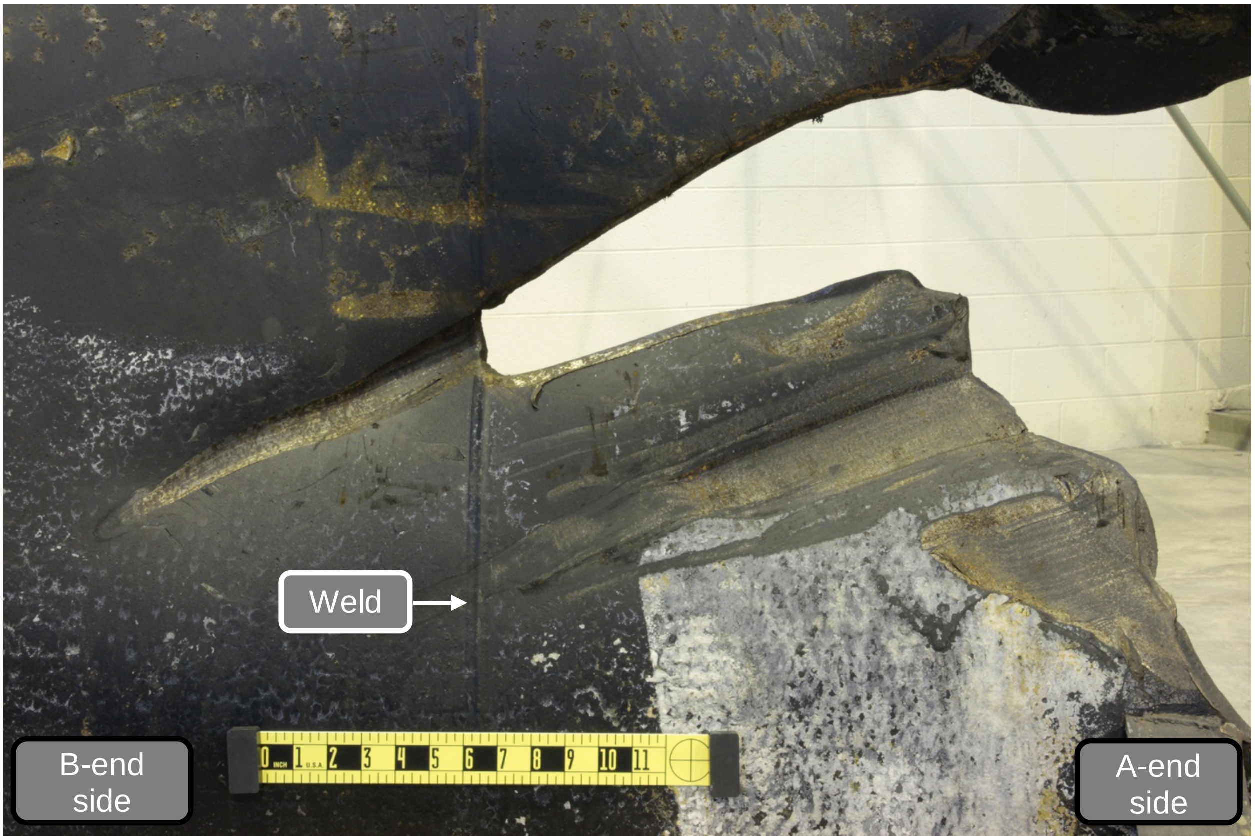


Figure 4: Image of the outside of the tank car shell showing the site, near a circumferential weld, where the breach initiated.

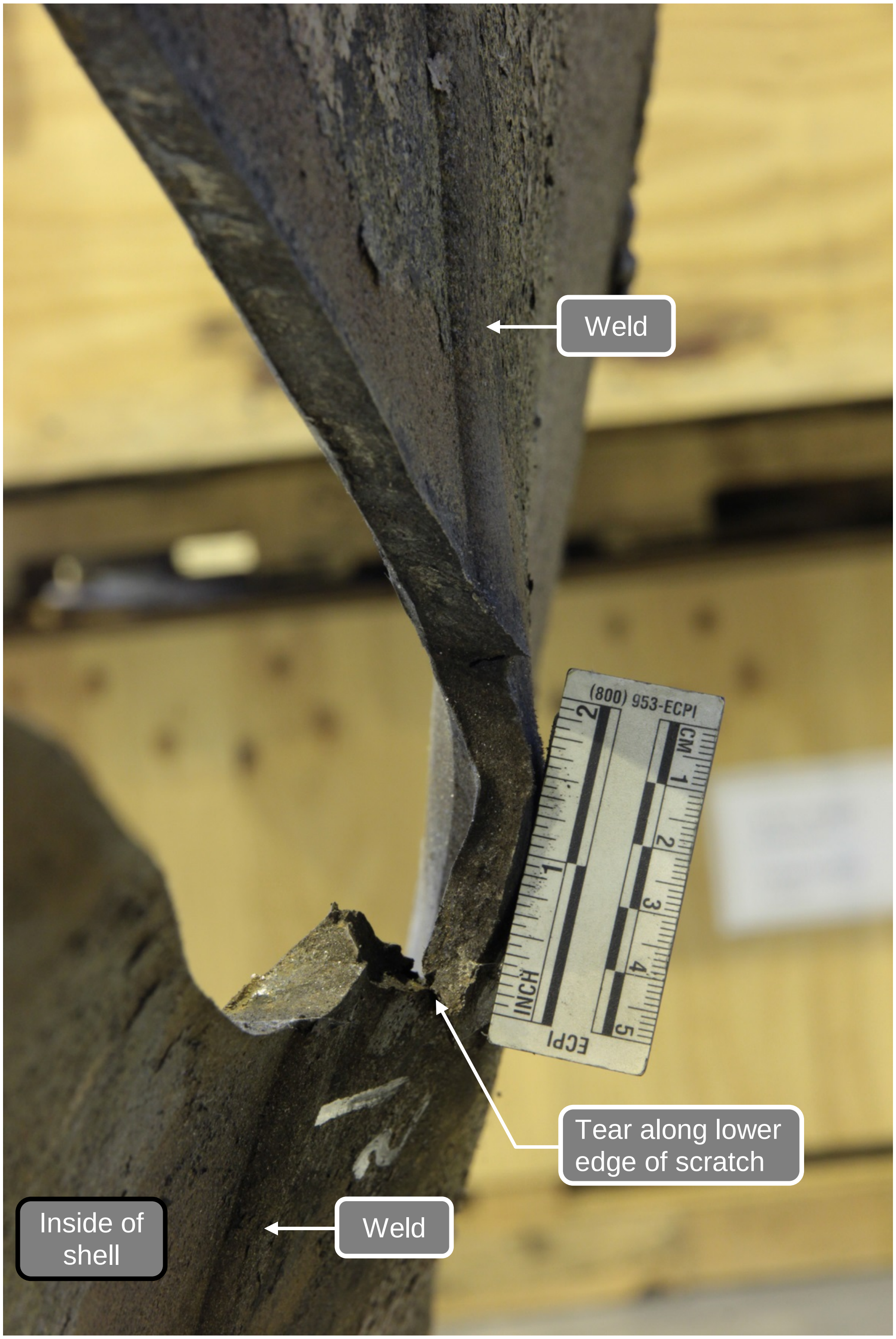


Figure 5: View of where the breach initiated, looking down the longitudinal axis toward the B-end of the tank car.

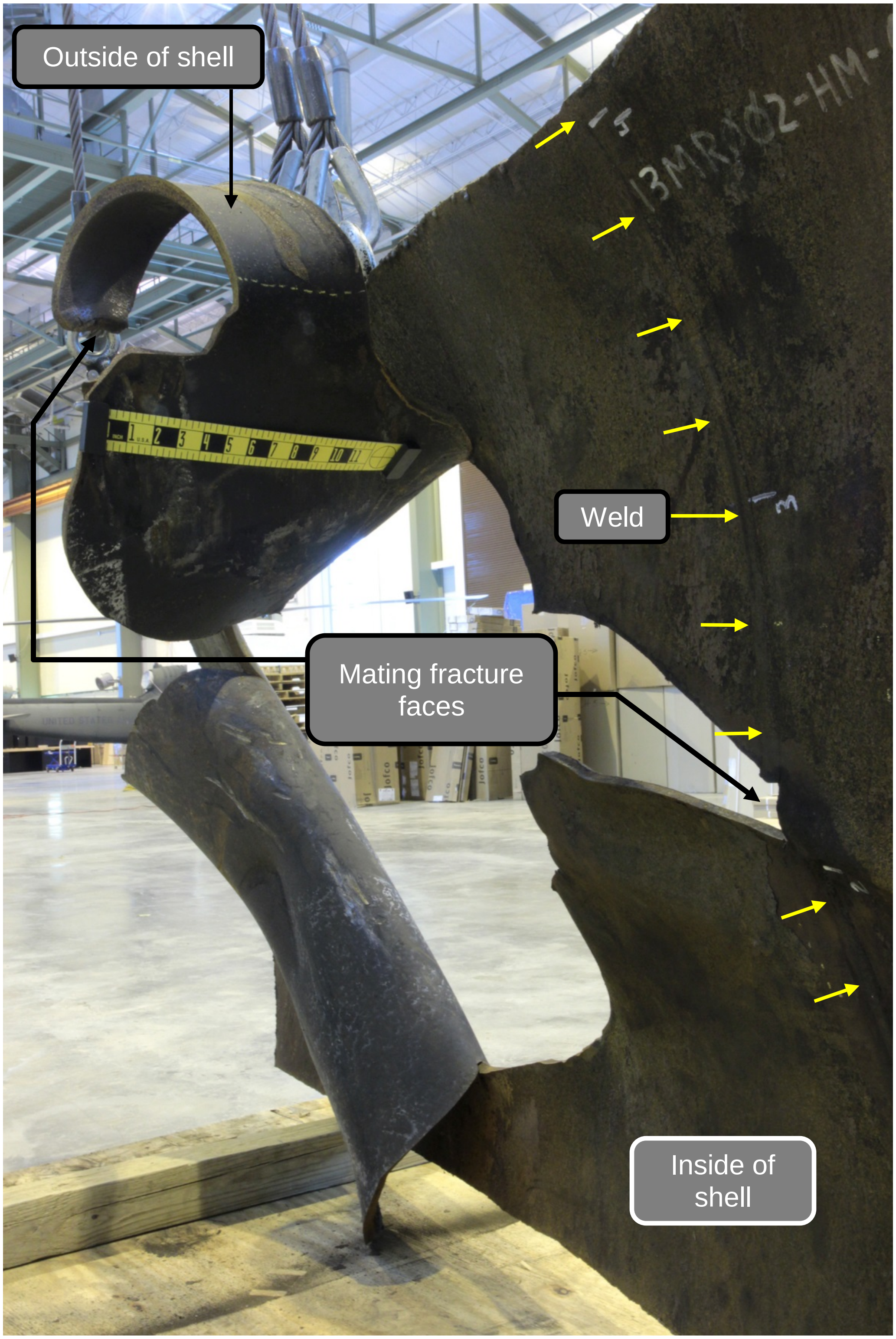


Figure 6: Image of the inside of the shell showing the curling deformation of the material that was pushed inward.

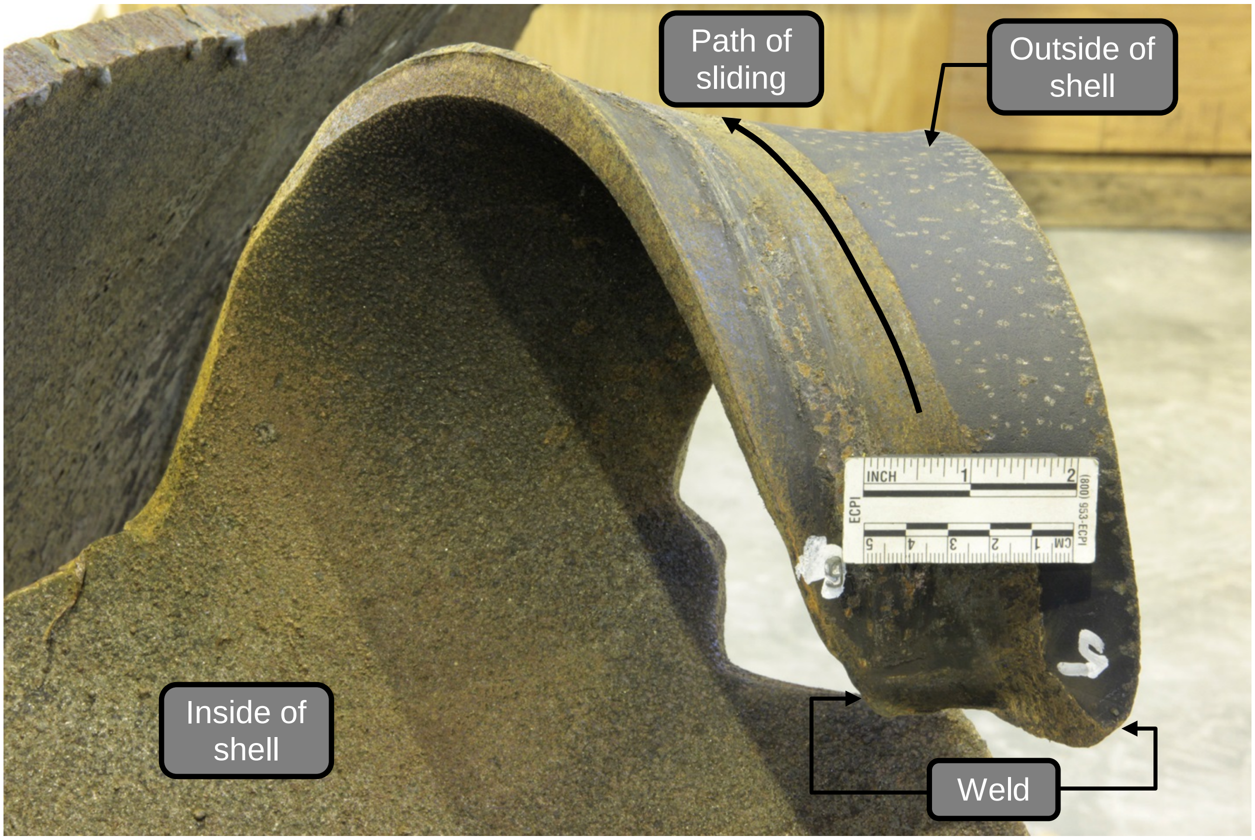


Figure 7: Image of the material between the two tears peeled inward on the A-end side of the weld where the breach initiated.

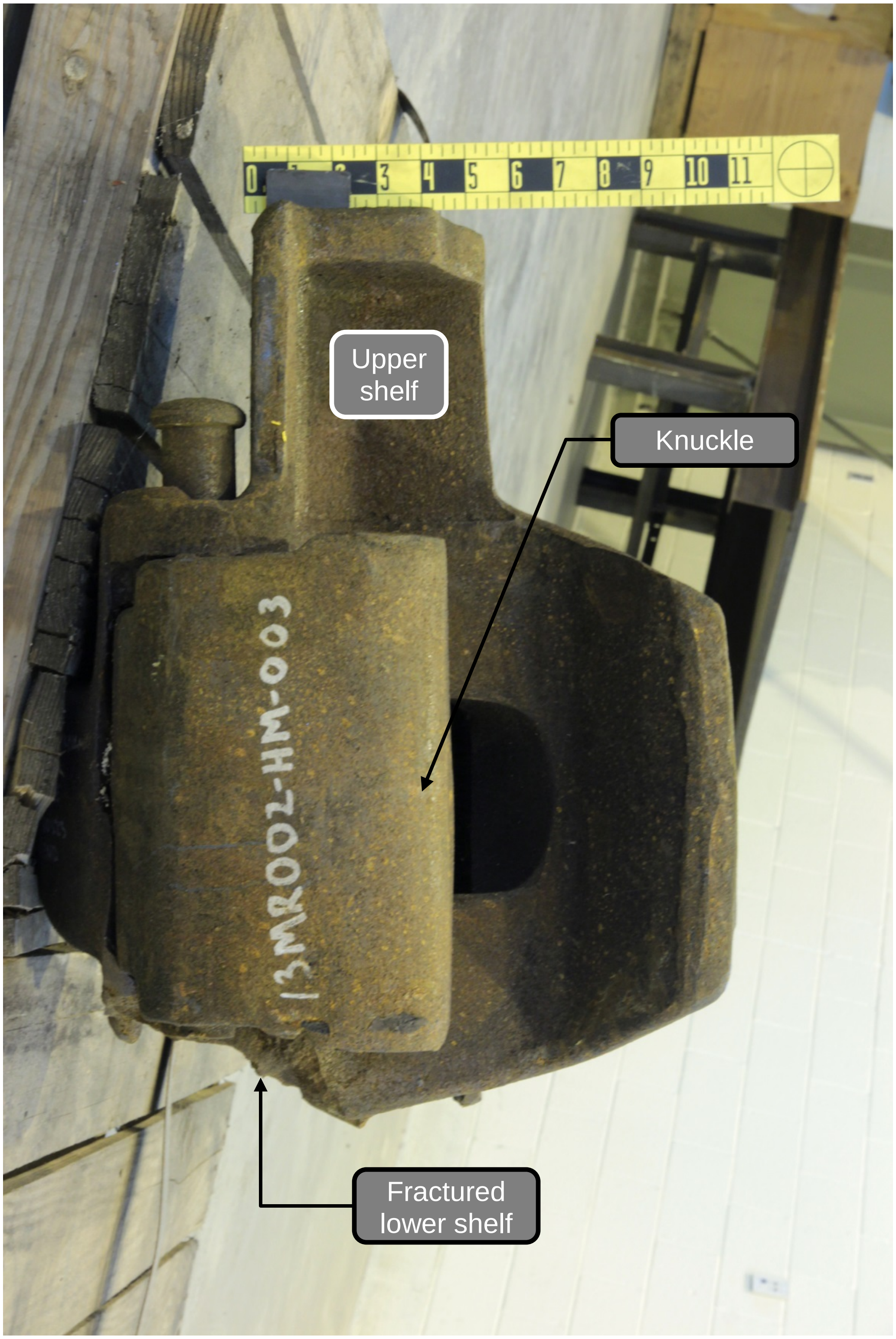


Figure 8: Image of the tank car coupler viewed from the trailing end.

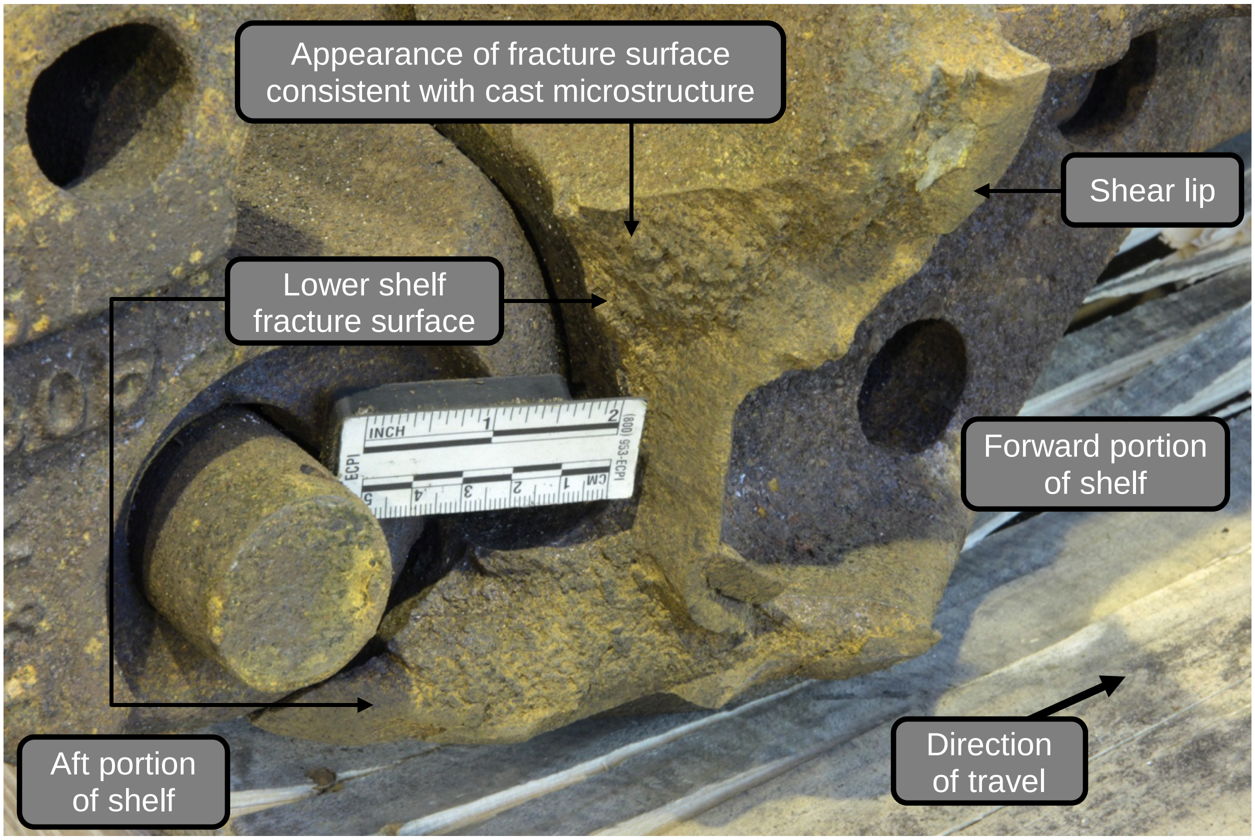


Figure 9: Image of the lower shelf fracture surface. The fracture features were consistent with an overstress fracture in forward bending.

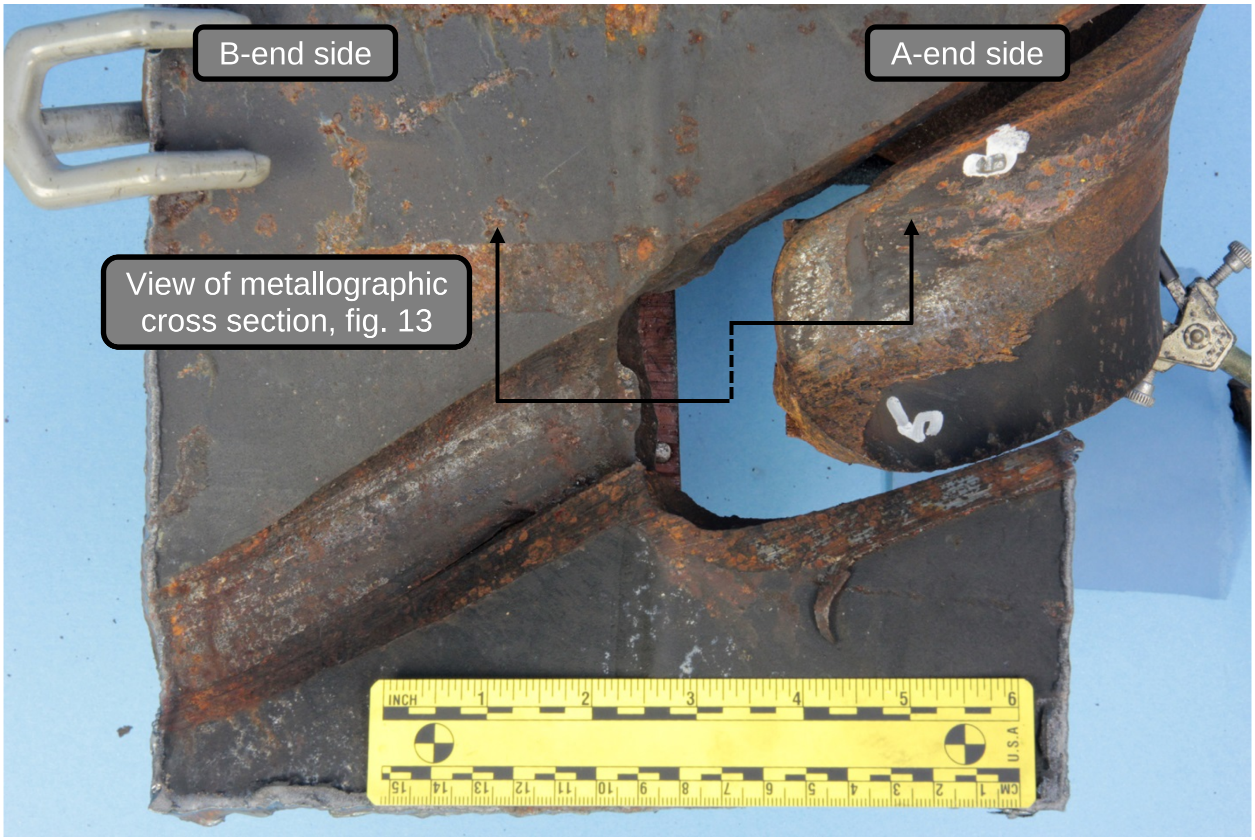
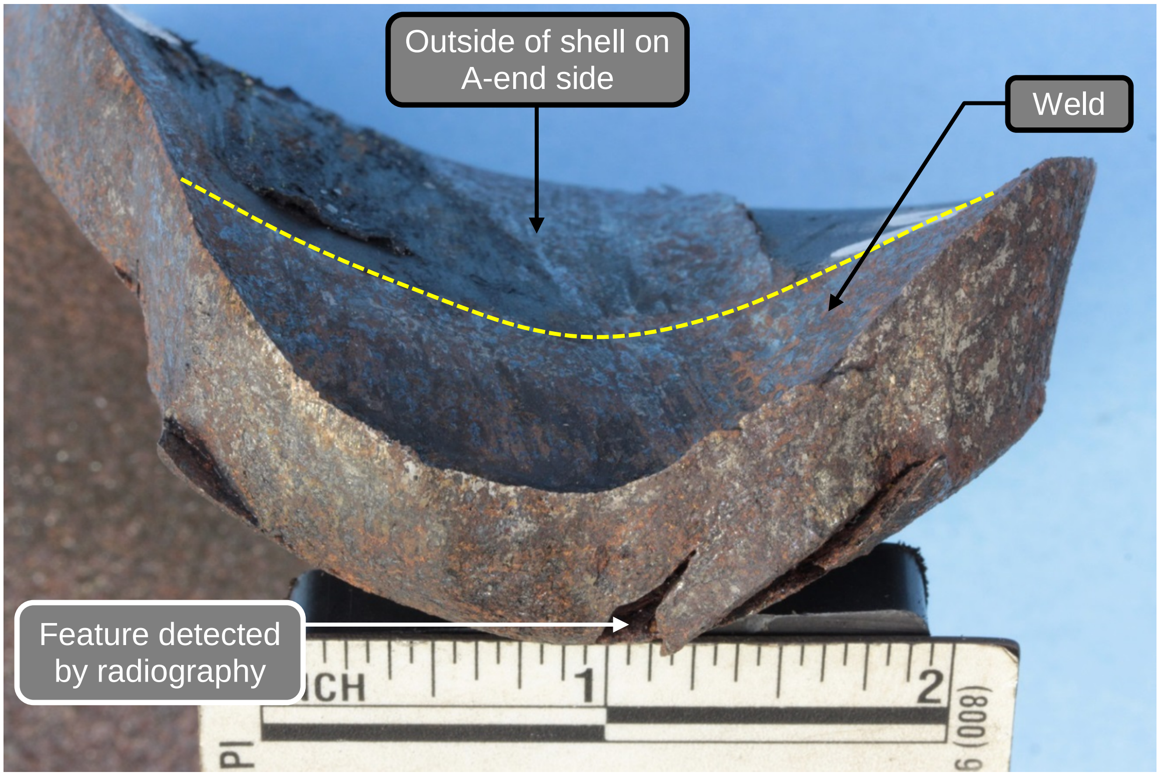


Figure 10: Area cut out of the tank car where the breach initiated. A metallographic cross section was prepared through the weld as indicated by the black arrows and shown in figure 13 below.

a)


b)


Figure 11: Images of the mating fracture faces at the toe of the circumferential weld where the breach initiated: a) side of fracture containing weld material and shell material on the A-end side of the weld. The yellow-dashed line indicates the location of the weld toe on the A-end side of the weld; b) side of fracture containing shell material on B-end side of the weld.

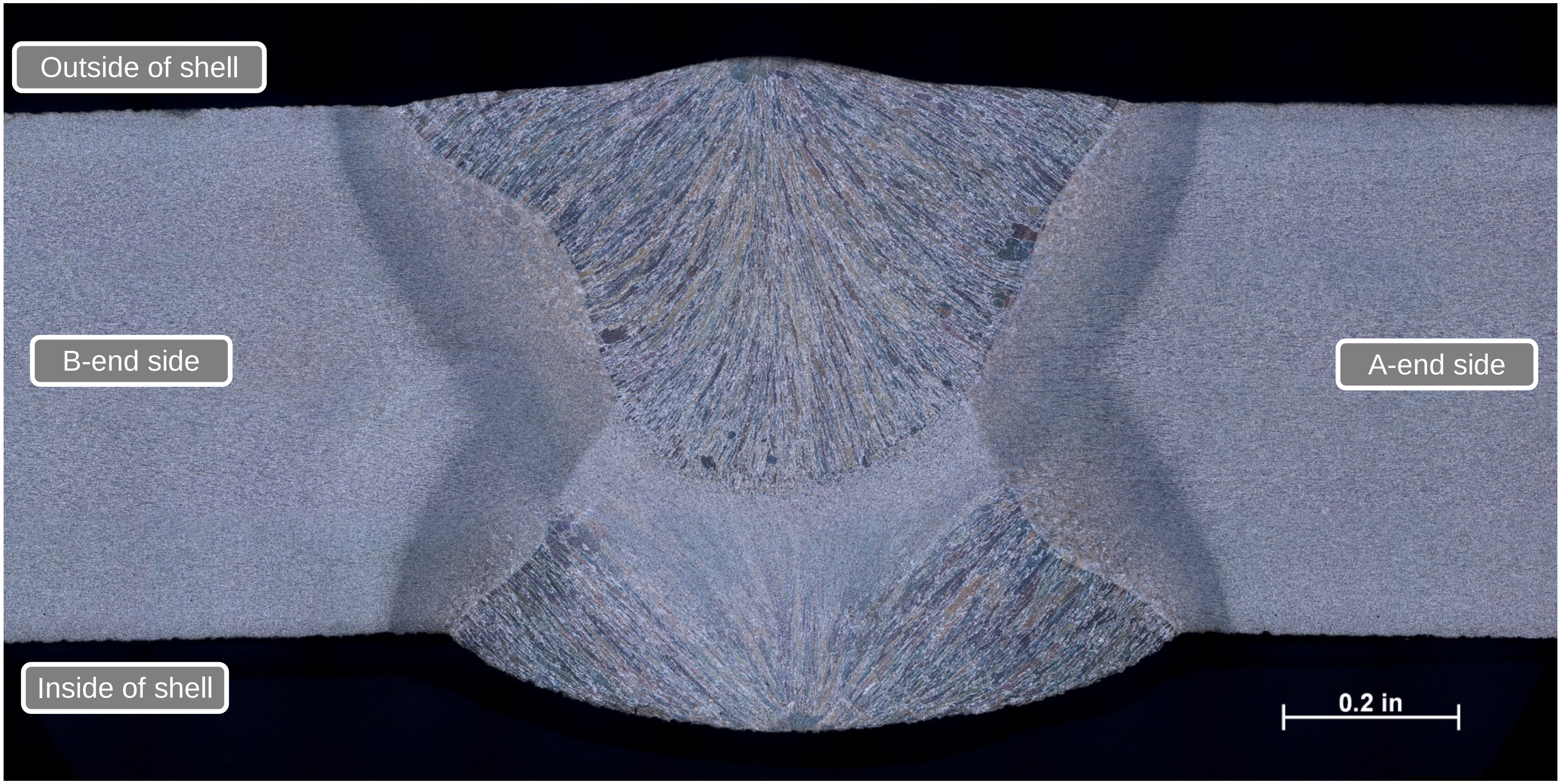


Figure 12: Metallographic cross section of the circumferential DSAW weld from the undamaged tank car section.

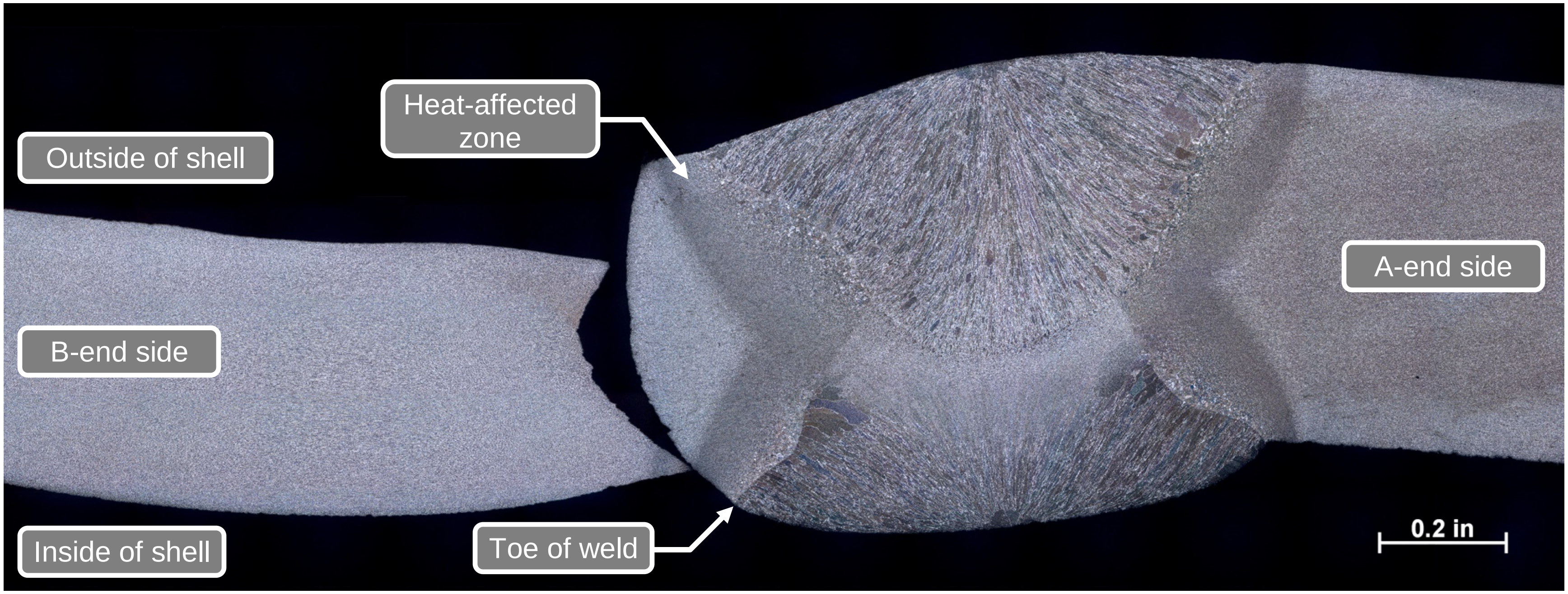


Figure 13: Metallurgical cross section through the circumferential weld where the breach initiated.

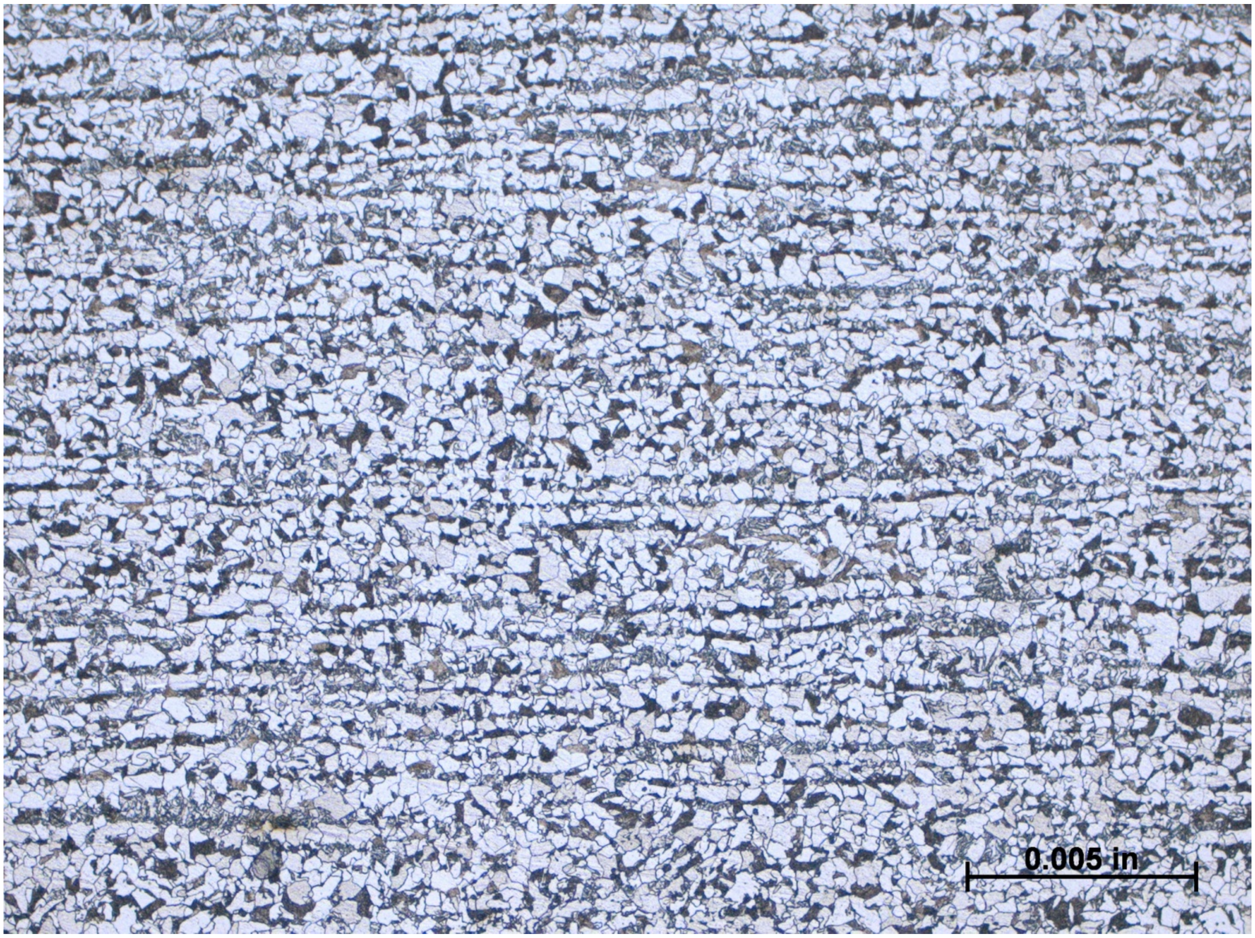
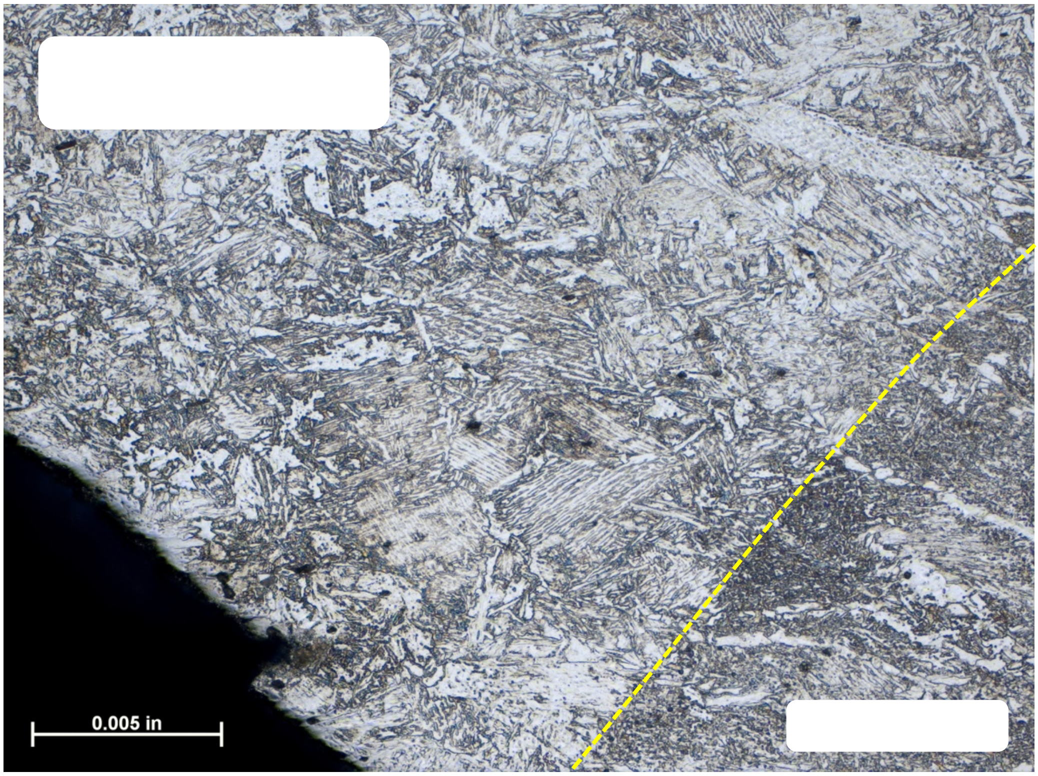
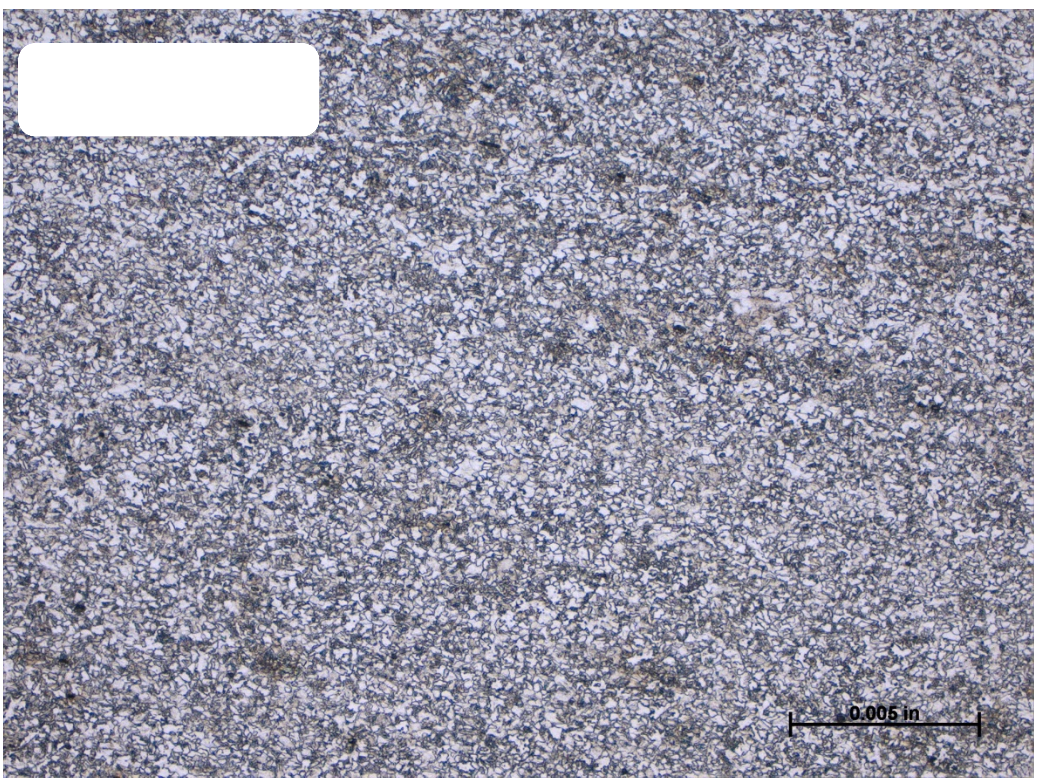


Figure 14: Typical microstructure consistent with the grain size requirements of TC 128 grade B material.



a)



b)

Figure 15: Microstructure of the heat-affected zone next to the fracture; a) the mictrostructure adjacent to the fusion zone had a coarse grain appearance with occasional proeutectoid ferrite along prior austenite grain boundaries and Widmanstätten ferrite with secondary phases; b) with increasing distance from the fusion zone, the grain size became increasingly refined.

Appendix A: Radiographic Inspection Report

MQC Labs, Inc.

Main Office
1550 S. Philadelphia Blvd., Aberdeen MD 21001
Phone: 410-575-7295 Fax: 410-272-5937

Branch Office
11593 Edmonston Rd., Beltsville, MD 20705
Phone: 301-931-0590 Fax: 301-931-0632

Radiographic Inspection Report

DT No. 44227 Date 9-25-13 Time of Completion N/A

Contractor N.T.S.B. Project RT OF TANKER CAR WALL

PO No. N/A Component No. SEE EXP. ID.

Material CFE Thickness 0.56" Reinforcement 0.06" IQI ASTM 1B Joint Type BUTT

Exposure Tech SWE / SWV Source to Film Distance 26" UG Factor SAT Original ☑ Repair ☐ No. N/A

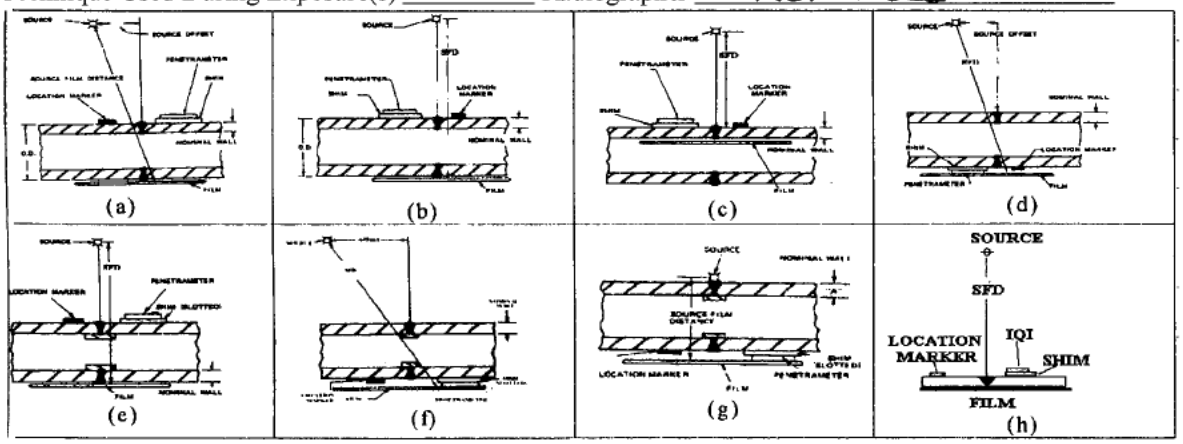
Procedure Spec. MQC RT-1 REV. 4 Interpretation Std. AAR MANUAL OF STD. & REC. PRAC., SPEC. FOR TANK CARS Class/Grade 11.2

X-Ray Machine S/N N/A Focal Spot N/A Ir-192 Isotope S/N 98318B Phys. Dimen. 0.122"

KV N/A MA N/A Time N/A Curies CONF. Exposure Time 9 MIN.

Film Type AGFA D4 Size 4.5"x17" Screens Pb - 0.01" Per Exposure ONE Per Cassette ONE

Technique Used During Exposure(s) H Radiographer RON NOLL NDT Level II



Technique Remarks

Exposure Identification	View	ACCEPT	REJECT	SLAG	POROSITY	L.O.F.	I.P.	CONCAVITY	BURN THROUGH	UNDERCUT	CRACK	OTHER	Quality Level	Film Density	Remarks
W-001	0-1	✓										✓	6	2.3-2.5	film artifact
	1-2	✓											6	2.7-2.8	
	2-3	✓										✓	6	2.3-2.5	film Artifact
	3-4	✓											6	2.7-2.8	
	5-6		X								X		6	2.5-3.0	
W-002	0-1	✓										✓	6	2.4-2.6	film artifact
	1-2	✓											6	2.5-2.6	
	2-3	✓											6	2.6-2.8	

 ✓ – Acceptable X – Rejectable Radiographer [redacted] NDT Level II

Appendix B: Mechanical Testing Report

Lehigh Testing Laboratories, Inc.
A Subsidiary of THE MMR GROUP, INC.
308 WEST BASIN ROAD • P.O. BOX 903 • NEW CASTLE, DE 19720
(302) 328-0500 • FAX (302) 328-0417

THE MMR GROUP, INC.
an ESOP Company

TEST REPORT

NATIONAL TRANSPORTATION SAFETY BOARD
ATTENTION: DON KRAMER
490 L'ENFANT PLAZA EAST
WASHINGTON, DC 20594

DATE: October 7, 2013

PO NO: **VERBAL**

LEHIGH NO: **P-57-22**
Samples 1 & 2

PAGE: 1 of 1

MATERIAL: AAR TC123 GRADE B
SAMPLE DESIGNATION: (2) SAMPLES: 8-1/2" X 11" X 9/16" NOMINAL WALL SECTION OF PIPE "A-END" & "B-END"

MECHANICAL PROPERTIES (Per ASTM A370-12a)

	#1 "A-END"			**#2 "B-END"**		
	A	**B**	**C**	**A**	**B**	**C**
Width (inches):	1.494	1.506	1.483	1.508	1.491	1.498
Thickness (inches):	0.618	0.620	0.619	0.611	0.610	0.613
Area (square inches):	0.9233	0.9337	0.9180	0.9214	0.9095	0.9183
Yield Point (ksi): 0.5% EUL:	66	66	69	65	65	65
Yield Point (ksi): 0.2% offset:	66	67	70	65	66	66
Ultimate Tensile Strength (ksi):	89	88	91	87	87	87
Elongation (%) in 2":	35	36	35	36	35	38

Based on the above testing this material meets the customer requirements of minimum yield 50 ksi, ultimate tensile 81 to 101 ksi, 22% minimum elongation.

Results are for information only.

Lehigh Testing Laboratories, Inc.

[redacted]

Kenneth M. Petito, Supvr., Mechanical Testing

Lehigh Testing Laboratories, Inc.
A Subsidiary of THE MMR GROUP, INC.
308 WEST BASIN ROAD • P.O. BOX 903 • NEW CASTLE, DE 19720
(302) 328-0500 • FAX (302) 328-0417

THE MMR GROUP, INC.
an ESOP Company

TEST REPORT

NATIONAL TRANSPORTATION SAFETY BOARD
ATTENTION: DON KRAMER
490 L'ENFANT PLAZA EAST
WASHINGTON, DC 20594

DATE: October 7, 2013

PO NO: **VERBAL**

LEHIGH NO: **P-57-22**
Sample 3

MATERIAL: AAR TC123 GRADE B
SAMPLE DESIGNATION: (1) SAMPLE: 8-1/2" X 11" X 9/16" NOMINAL WALL SECTION OF PIPE "BUTT WELD"

MECHANICAL PROPERTIES (Per ASTM A370-12a)

	#3 "BUTT WELD"		
	A	**B**	**C**
Width (inches):	1.486	1.492	1.492
Thickness (inches):	0.578	0.582	0.578
Area (square inches):	0.8589	0.8683	0.8624
Ultimate Tensile Strength (ksi):	93	92	92
Elongation (%) in 2":	31	32	29
Location & Character of Failure:	Base/ Ductile	Base/ Ductile	Base/ Ductile

Based on the above testing this material meets the customer requirements of 22% minimum elongation and Weld: Minimum tensile 81 ksi.

Results are for information only.

Lehigh Testing Laboratories, Inc.

[redacted]

Kenneth M. Petito, Supvr., Mechanical Testing

Appendix C: Mill Test Reports

USS A DIVISION OF USX CORPORATION 01.000.0772 (REV. 4/87)

TF TR 10/03/90 by

Test Report

17629

JOB, CONTRACT NO.	P.O. DATE	PURCHASE ORDER NO.		
	06/29/90	DRC010369		
	SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
	HQB794 10 02 90		US57135	154-092758
	VEHICLE IDENTITY EJE 008072			HB794

VENDOR:
GARY WORKS
GARY, INDIANA 46402

SOLD TO:
TRINITY INDUSTRIES
TANKCAR DIV PURCHASING
SUITE 625 - ATTN E L BROWN
PO BOX 568887
DALLAS TX 75356-8887

SHIP TO:
TRINITY INDUSTRIES
RAILCAR DIV
PLANT 22
1000 NE 28TH ST
FORT WORTH TX 76106

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MFGD., SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS REQUIREMENTS IN SUCH RESPECT. 84

PREPARED BY THE OFFICE OF.
J. J. HARRINGTON Q. A. MGR.

DATE 10-3-90

PART NO: PT#P20068--

SPEC. & INSP.: PLATE CARBON AAR TC128-85 GRADE B PRESSURE VESSEL QUALITY NORMALIZE PLATE STRESS RELIEVE TEST SPECIMENS ONLY 1125 DEG F PLUS/MINUS 25 DEG F HOLD ONE (1) HOUR MINIMUM PER AAR TANK CAR SPEC W17.00 REST THICK TOL PLUS STD MINUS .010 MAX

INSP: 01 MILL RA/SN CERTIFIED T/R ANALYSIS ORIGINAL TEST REPORT AND (1) COPY VIA AIRMAIL TO SHIP TO ATTN LEROY HARPER ONE (1) T/R TELECOPIED TO 817/626-8719 ATTN LEROY HARPER ONE (1) T/R COPY VIA

ITEM NO.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION % IN 8"	ELONGATION % IN 2"	% RED. OF AREA	BEND
01	.5725	119.2500	376- 5/8 "	01	7292	T04824	55X 1 *	68500	89500	22.0	40.0		
PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.													
01	.5725	119.2500	376- 5/8 "	01	7292	T04824	55X 2 *	69000	91000	24.0	42.0		
PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.													
01	.5725	119.2500	376- 5/8 "	01	7292	T04824	55Y 2 *	69500	91000	22.0	38.0		
END OF DATA													
*YIELD STRENGTH @ 0.5% E. U. L.													

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO	
T04824	HEAT	22	127	012	004	21	27	18	017	05		0033		072			000		FINE GRAIN
END OF DATA																			

MATRIX DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

A DIVISION OF USX CORPORATION
01.000.0772 (REV. 4/87)

Metallurgical
Test Report

19652

JOB, CONTRACT NO.	P.O. DATE	PURCHASE ORDER NO.		
	06/29/90	DRC010369		
	SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
	H08829	10 09 90	US57135	154-093507
	VEHICLE IDENTITY	EJE 006050		H8829

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WA MFGD, SAMPLED, TESTED AND/ INSPECTED IN ACCORDANCE WIT THE SPECIFICATION AND FUL- FILLS REQUIREMENTS IN SUCH RESPECT.

BY

PREPARED BY THE OFFICE OF
J. J. HARRINGTON G. 4 MG

DATE 10-10-90

VENDOR:
GARY WORKS
GARY, INDIANA 46402

SOLD TO:
TRINITY INDUSTRIES
TANKCAR DIV PURCHASING
SUITE 625 - ATTN E L BROWN
PO BOX 568887
DALLAS TX 75356-8887

SHIP TO:
TRINITY INDUSTRIES
RAILCAR DIV
PLANT 22
1000 NE 28TH ST
FORT WORTH TX 76106

PART NO: PT#P20068--

C. PLATE CARBON AAR TC128-85 GRADE B PRESSURE VESSEL QUALITY
P. NORMALIZE PLATE STRESS RELIEVE TEST SPECIMENS ONLY 1125 DEG F
PLUS/MINUS 25 DEG F HOLD ONE (1) HOUR MINIMUM PER AAR TANK CAR
SPEC W17.00 REST THICK TOL PLUS STD MINUS .010 MAX
NSP 01 MILL RA/SN CERTIFIED T/R ANALYSIS ORIGINAL TEST REPORT AND (1)
COPY VIA AIRMAIL TO SHIP TO ATTN LEROY HARPER ONE (1) T/R
TELECOPIED TO 817/626-8719 ATTN LEROY HARPER ONE (1) T/R COPY VIA

ITEM NO.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION% IN 8"	ELONGATION% IN 2"	% RED. OF AREA	BEND
01	.5725	119.2500	376- 5/8 "			T04824							
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04824	57Y 1 *	67000	89000	20.0	40.0		
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04824	57Y 2/ *	68500	89500	23.0	40.0		
	END OF DATA												
	*YIELD STRENGTH @ 0.5% E.U.L.												

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO	
04824	HEAT	22	127	012	006	21	27	16	017	05		0033		072			000		FINE GRAIN
	END OF DATA																		

TRIX

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

USS A DIVISION OF USX CORPORATION
01.000.0772 (REV. 4/87)

Metallurgical Test Report

19662

JOB, CONTRACT NO.	P.O. DATE	PURCHASE ORDER NO.		
	06/29/90	DRC010369		
	SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
	H08796	10 09 90	US57135	154-093509
	VEHICLE IDENTITY	EJE 008141		H8796

GARY WORKS
GARY, INDIANA 46402

TRINITY INDUSTRIES
TANKCAR DIV PURCHASING
SUITE 625 - ATTN E L BROWN
PO BOX 568887
DALLAS TX 75356-8887

SHIP TO:
TRINITY INDUSTRIES
RAILCAR DIV
PLANT 22
1000 NE 28TH ST
FORT WORTH TX 76106

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WA[S] MFGD., SAMPLED, TESTED AND/[OR] INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS REQUIREMENTS IN SUCH RESPECT. BY

PREPARED BY THE OFFICE OF
J. J. HARRINGTON Q. A MG[R]

DATE 10-10-90

PART NO: PT#P20068--
PLATE CARBON AAR TC128-85 GRADE B PRESSURE VESSEL QUALITY
NORMALIZE PLATE STRESS RELIEVE TEST SPECIMENS ONLY 1125 DEG F
PLUS/MINUS 25 DEG F HOLD ONE (1) HOUR MINIMUM PER AAR TANK CAR
SPEC W17.00 REST THICK TOL PLUS STD MINUS .010 MAX
[D]ISP: 01 MILL RA/SN CERTIFIED T/R ANALYSIS ORIGINAL TEST REPORT AND (1)
COPY VIA AIRMAIL TO SHIP TO ATTN LEROY HARPER ONE (1) T/R
TELECOPIED TO 817/626-8719 ATTN LEROY HARPER ONE (1) T/R COPY VIA

ITEM NO.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION% IN 8"	ELONGATION% IN 2"	%RED. OF AREA	BEN[D]
01	.5725	119.2500	376- 5/8 "			T04825							
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04825	55Y 1 *	67500	90000	22.0	43.0		
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04825	55Y 2 *	65500	86500	24.0	43.0		
	END OF DATA												
	*YIELD STRENGTH @ 0.5% E.U.L.												

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO	
04825	HEAT	22	128	013	007	20	28	16	017	05		0027		069			000		FINE GRAIN
	END OF DATA																		

TR1X DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

A DIVISION OF USX CORPORATION
01.000.0772 (REV. 4/87)

Metallurgical Test Report

19664

JOB, CONTRACT NO.	P.O. DATE	PURCHASE ORDER NO.		
	06/29/90	DRC010369		
	SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
	H08796 10 09 90		US57135	154-093509
	VEHICLE IDENTITY	EJE 008141		H8796

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WA MFGD, SAMPLED, TESTED AND/ INSPECTED IN ACCORDANCE WIT THE SPECIFICATION AND FUL- FILLS REQUIREMENTS IN SUCH RESPECT.

BY

PREPARED BY THE OFFICE OF
J. J. HARRINGTON Q. A MG

DATE 10-10-90

VENDOR:
GARY WORKS
GARY, INDIANA 46402

SOLD TO:
TRINITY INDUSTRIES
TANKCAR DIV PURCHASING
SUITE 625 - ATTN E L BROWN
PO BOX 568887
DALLAS TX 75356-8887

SHIP TO:
TRINITY INDUSTRIES
RAILCAR DIV
PLANT 22
1000 NE 28TH ST
FORT WORTH TX 76106

PART NO: PT#P20068--

C. PLATE CARBON AAR TC128-85 GRADE B PRESSURE VESSEL QUALITY
P. NORMALIZE PLATE STRESS RELIEVE TEST SPECIMENS ONLY 1125 DEG F
PLUS/MINUS 25 DEG F HOLD ONE (1) HOUR MINIMUM PER AAR TANK CAR
SPEC W17.00 REST THICK TOL PLUS STD MINUS .010 MAX
NSP: 01 MILL RA/SN CERTIFIED T/R ANALYSIS ORIGINAL TEST REPORT AND (1)
COPY VIA AIRMAIL TO SHIP TO ATTN LEROY HARPER ONE (1) T/R
TELECOPIED TO 817/626-8719 ATTN LEROY HARPER ONE (1) T/R COPY VIA

ITEM NO.	MATERIAL DESCRIPTION: THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION% IN 8"	ELONGATION% IN 2"	% RED. OF AREA	BE
01	.5725	119.2500	376- 5/8 "			T04825							
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04825	56Y 1 *	66000	87000	20.0	40.0		
	PRODUCT & TEST SPECIMENS WERE NORMALIZED AT 1660 DEG. F. FOR 0020 MINUTES. COOLING COMPLETED IN STILL AIR.												
01	.5725	119.2500	376- 5/8 "	01	7292	T04825	56X 2 ✓ *	68500	90500	21.0	41.0		
	END OF DATA												
	*YIELD STRENGTH @ 0.5% E.U.L.												

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO	
T04825	HEAT	22	128	013	007	20	28	16	017	05		0027		069			000		FINE GRAIN
	END OF DATA																		

MATRIX

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

Appendix D: Chemical Analysis Report

IMR
TEST LABS
A Business Unit of CWST

131 Woodsedge Drive
Lansing, NY 14882

Toll Free	1.888.464.8422
Phone	1.607.533.7000
Fax	1.607.533.9210
Email	imr@imrtest.com
Web	www.imrtest.com

October 7, 2013

Don Kramer
National Transportation
Safety Board
490 L'Enfant Plaza
Washington, DC 20594

TEST REPORT

IMR Report Number 201310265

PO Number
Credit Card

Date Received
October 2, 2013

Sample ID
A-end, B-end

Material
Carbon Steel

Description
Tank car steel

Specification(s)
AAR TC 128 Grade B

SUMMARY

Two samples were received for chemical analysis.

The samples **meet** the chemical requirements of AAR TC 128 for a Grade B carbon manganese steel plate.

The results are on the following page(s).

A2LA ACCREDITED Testing Cert # 1140.01 & 1140.02

Accredited Nadcap Materials Testing Laboratory

Reviewed by
[redacted]
Cheryl Downey
Report Review Specialist

Reviewed by
[redacted]
Jamie Wech for
Peter Damian, Director
Chemistry Department

CHEMISTRY

Element	A-end	B-end	Specification
C[1]	0.22	0.21	0.26 Maximum
Mn	1.30	1.30	1.00 - 1.70
P	0.012	0.014	0.025 Maximum
S[1]	0.007	0.008	0.015 Maximum
Si	0.21	0.20	0.13 - 0.45
V	0.078	0.072	0.084 Maximum
Cu	0.27	0.28	0.35 Maximum
Ni	0.16	0.16	---
Cr	0.17	0.16	---
Mo	0.06	0.06	---
Al	0.03	0.04	0.015 - 0.060
Nb	<0.01	<0.01	0.03
Ti	0.001	0.002	0.020 Maximum
B	0.0002	0.0003	0.0005 Maximum
N[2]	0.006	0.006	0.012 Maximum
Sn	<0.001	<0.001	0.020 Maximum
CEq	---	---	0.55 Maximum
Cu + Ni + Cr + Mo	0.66	0.66	0.65 Maximum
Nb + V + Ti	0.08	0.07	0.11 Maximum
Ti / N	0.17	0.33	4.0 Maximum

[1]Determined by combustion-infrared absorbance.
[2]Detrermined by inert gas fusion-thermal conductivity.
Results are in weight percent unless otherwise indicated.
Method(s): ASTM E 415-08 (OES) and ASTM E 1019-11 (Comb./IGF)

Appendix E: TC 128 Grade B Chemical Requirements from previous revisions of the AAR Manual of Standards and Recommended Practices Section C-III – Specifications for Tank Cars

Notes:
1. Not for parts subject to tank internal pressure
2. Option for hydrostatic test may be specified
3. Not for pressure car or DOT-111A100W4 parts subject to tank internal pressure

M4.07 EXTERIOR COIL MATERIALS

In addition to the plate materials specified in Table M1, the following plate, shape and strip materials are approved for exterior heater coils:

Carbon Steel:	ASTM A36 Structural Steel
	ASTM A113 Structural Steel, Grade B
	ASTM A414 Sheets, Grade C
	ASTM A569 Sheet or Strip
	ASTM A570 Sheet or Strip, Grade C
	ASTM A659 Sheet or Strip, Grade 1015
	SAE 1015 Sheet or Strip, Silicon Killed
Stainless Steel:	ASTM A240 Types 304, 304L, 316, 316L
Aluminum:	ASTM B221 Extruded Shapes, 6061-T4, T6

M128.00 SPECIFICATION FOR HIGH STRENGTH CARBON MANGANESE STEEL PLATES FOR TANK CARS — AAR TC128. (THIS SPECIFICATION COVERS THE SAME STEEL AS ASTM A612 WITH CARBON MAXIMUM OF 0.25 PERCENT)

M128.01 SCOPE

(a) This specification covers one grade of high strength carbon-manganese steel plate for use in fusion welded tanks. The maximum thickness must be 1 inch. Moderately high manganese content, together with small amounts of other elements provide for high strength with limited carbon content. The steel must be made to fine grain practice. Welding technique is of fundamental importance, and it is presupposed that welding procedure will be in accord with good practice.

(b) The material must be furnished in the as-rolled or normalized condition. When specified for low temperature service the material must be furnished normalized to meet the Charpy V-Notch energy absorption requirements of 15 ft-lb minimum average for 3 specimens and 10 ft-lb minimum for one specimen at minus 50F in the longitudinal direction of rolling in accord with ASTM A370.

M128.02 GENERAL CONDITIONS FOR DELIVERY

Material furnished under this specification must conform to the applicable requirements of ASTM A20 titled, "General Requirements for Delivery of Steel Plates for Pressure Vessels," except, when specified for low temperature service, refer to M128.01(b) for the energy absorption requirement only.

M128.03 PROCESS

The steel must be made by one of the following processes:

(1) Open hearth,
(2) Electric furnace, or
(3) Basic oxygen.

M128.04 CHEMICAL COMPOSITION

The steel must conform to the requirements as to chemical composition prescribed in Table M128.04.

TABLE M128.04

CHEMICAL REQUIREMENTS

Element		Ladle Analysis, Percent
		Grade B
Carbon	Max.	0.25
Manganese		
For plates 3/4" and under in thickness		1.00-1.35
For plates over 3/4" to 1" incl. in thickness		1.00-1.50
Phosphorus	Max.	0.035
Sulfur	Max.	0.040
Silicon		
For plates 3/4" and under in thickness		0.15-0.30
For plates over 3/4" to 1" incl. in thickness		0.15-0.50
Vanadium a/	Max.	0.08
Copper a/	Max.	0.35
Nickel a/	Max.	0.25
Chromium a/	Max.	0.25
Molybdenum a/	Max.	0.08

a/ These elements will be reported when requested by the purchaser.

M128.05 TENSILE PROPERTIES

The material as represented by the test specimens must conform to the requirements as to tensile properties prescribed in Table M128.05.

TABLE M128.05

TENSILE REQUIREMENTS

Property		Grade B
Tensile strength, psi		81,000 to 101,000
Yield strength, psi	Min.	50,000
Elongation in 8 inches percent	Min.	16.0 a/
Elongation in 2 inches percent	Min.	22.0

a/ For material under 5/16 inch thick a reduction from the specified percent of elongation of 1.25 percent must be made for each decrease of 1/32 inch of thickness below 5/16 inch. For material over 3/4 inch thick a reduction from the specified percent elongation of 0.5 percent must be made for each increase of 1/8 inch of the thickness above 3/4 inch; this reduction must not exceed 3 percent.

M128.06 Open.

M128.07 TEST SPECIMENS

Test specimens furnished by the steel manufacturer must be prepared from the material in the condition specified for the plate use, such as, as-rolled, normalized or postweld heat treated.

M128.08 NUMBER OF TESTS

One tension test must be made from each plate-as-rolled.

Note: The term "plate-as-rolled" used here refers to the unit plate rolled from a slab or directly from an ingot in its relation to the location and number of specimens, not to its condition.

M128.09 INSPECTION

(a) The inspector representing the purchaser shall have free entry, at all times while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities and necessary assistance to satisfy him that the material is being furnished in accord with these specifications. Tests and inspection must be made at the place of manufacture prior to shipment, unless otherwise specified.

(b) The purchaser may make tests to cover the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests must be made at the expense of the purchaser.

M128.10 REJECTION

(a) Material represented by samples which fail to conform to the requirements of these specifications will be rejected.

(b) Material which shows injurious defects subsequent to its original inspection and acceptance at the manufacturer's works, or elsewhere, will be rejected, and the manufacturer must be notified.

M128.11 REHEARING

Samples tested in accord with these specifications which represent rejected material, must be held for a period of fourteen days from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

M133.00 SPECIFICATION FOR HIGH-STRENGTH NINE PER CENT NICKEL ALLOY STEEL PLATES, DOUBLE NORMALIZED AND TEMPERED — AAR TC133.

M133.01 SCOPE

(a) This specification covers high-strength nine per cent nickel alloy steel plates, double-normalized and tempered, for use in fusion welded tanks.

(b) Material furnished under this specification must conform to the requirements of ASTM A353 with modifications to chemical composition and impact requirements as follows:

M133.02 CHEMICAL COMPOSITION

The steel must conform to the additional requirements as to chemical composition prescribed in Table M133.02.

M4.07 EXTERIOR COIL MATERIALS

In addition to the plate materials specified in Table M1, the following plate, shape and strip materials are approved for exterior heater coils:

Carbon steel

ASTM A36 Structural Steel.
ASTM A414 Sheets, Grade C.
ASTM A569 Sheet and Strip.
ASTM A570 Sheet and Strip, Grade 33.
ASTM A607 Grade 50.
ASTM A659 Sheet and Strip, Grade 1015.
SAE 1015 Sheet or Strip, silicon killed.

Stainless steel

ASTM A240 Types 304, 304L, 316, 316L.

Aluminum

ASTM B221 Extruded Shapes, Alloy 6061-T4, -T6.

M128.00 SPECIFICATION FOR HIGH STRENGTH CARBON MANGANESE STEEL PLATES FOR TANK CARS—AAR TC128

M128.01 SCOPE

(a) This specification covers one grade of high strength carbon manganese steel plate for use in fusion welded tank car tanks. The maximum thickness must be 1 inch (25.4 millimeters). Moderately high manganese content, together with small amounts of other elements, provide for high strength with limited carbon content. The steel must be made to fine grain practice. Welding technique is of fundamental importance, and it is presupposed that welding procedure will be in accord with good practice.

(b) The material must be furnished in the as-rolled or normalized condition. When specified for low temperature service, the material must be furnished normalized to meet the Charpy V-notch energy absorption requirements of 15 ft-lb (20.3 joules) minimum average for 3 specimens, and 10 ft-lb (13.6 joules) minimum for one specimen, at minus 50F (minus 45.6°C) in the longitudinal direction of rolling, in accord with ASTM A370.

M128.02 GENERAL CONDITION FOR DELIVERY

Material furnished under this specification must conform to the applicable requirements of ASTM A20, titled "General Requirements for Steel Plates for Pressure Vessels", except, when specified for low temperature service, refer to M128.01(b) for the energy absorption requirement, only.

M128.03 PROCESS

The steel must be made by the open hearth, electric furnace or basic oxygen process.

M128.04 CHEMICAL COMPOSITION

The steel must conform to the chemical composition requirements prescribed in Table M128.04.

TABLE M128.04

CHEMICAL REQUIREMENTS

Element		Grade B Ladle Analysis, Percent	Grade B Product Analysis, Percent
Carbon	Max.	0.25	0.29
Manganese			
For plates ¾″ (19.0 mm) and under in thickness		1.00-1.35	0.92-1.46
For plates over ¾″ to 1″ (over 19.0 to 25.4 mm) in thickness		1.00-1.50	0.92-1.62
Phosphorus	Max.	0.035	0.035
Sulfur	Max.	0.040	0.040
Silicon			
For plates ¾″ (19.0 mm) and under in thickness		0.15-0.40	0.13-0.45
For plates over ¾″ to 1″ (over 19.0 to 25.4 mm) in thickness		0.15-0.50	0.13-0.55
Vanadium a/	Max.	0.08	0.08
Copper a/	Max.	0.35	0.35
Nickel a/	Max.	0.25	0.25
Chromium a/	Max.	0.25	0.25
Molybdenum a/	Max.	0.08	0.08

a/ These elements will be reported when requested by the purchaser.

M128.05 TENSILE PROPERTIES

The material as represented by the test specimens must conform to the tensile properties prescribed in Table M128.05.

TABLE M128.05

TENSILE REQUIREMENTS

Property		Grade B
Tensile strength, psi (MPa)		81,000 to 101,000 (560 to 695)
Yield strength, psi (MPa)	Min.	50,000 (345)
Elongation in 8 in. (200 mm) percent	Min.	16.0 a/
Elongation in 2 in. (50 mm) percent	Min.	22.0

a/ For material under 5/16 inch (7.94 mm) thick, a reduction from the specified percent elongation of 1.25 percent must be made for each decrease of 1/32 inch (0.794 mm) of thickness below 5/16 inch (7.94 mm). For material over 3/4 inch (19.0 mm) thick, a reduction from the specified percent elongation of 0.5 percent must be made for each increase of 1/8 inch (3.18 mm) of the thickness above 3/4 inch (19.0 mm). This reduction must not exceed 3 percent.

M128.06 Open.

M128.07 TEST SPECIMENS

Test specimens furnished by the steel manufacturer must be prepared from the material in the condition specified for the plate use, such as normalized, as-rolled or postweld heat treated.